

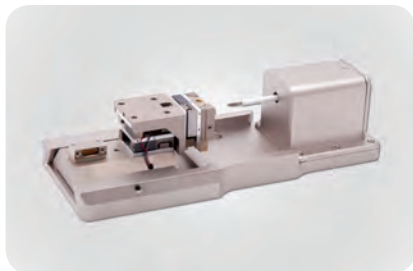
## Hysitron PI Series PicoIndenter

- Quantitative In-Situ Nanomechanics Inside Your SEM or TEM

# Hysitron PI Series

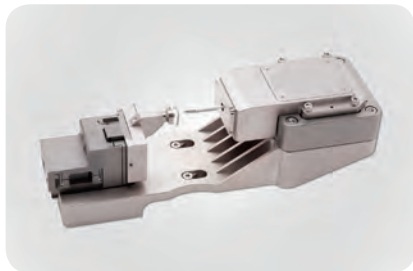
## Quantitative In-Situ Nanomechanics

As the world leader in nanomechanical testing systems, Bruker makes it easy for you to conduct in-situ mechanical experiments in your microscope with the Hysitron PI Series PicoIndenter. Our unique transducer design delivers unmatched stability throughout your experiments, resulting in precise data even at the nanoscale. Video capture from the microscope enables real-time monitoring and direct correlation of mechanical data to microscope imaging. With solutions designed to fit many of the microscope brands in use, you are sure to find one that is ideally suited to your research.



**Hysitron PI 85L SEM PicoIndenter**  
Versatile In-Situ Mechanical Testing Platform

- Mounts directly to SEM stage for easy installation and superior stability
- Designed for maximum sample tilt and minimum working distance
- Features a low profile design ideal for SEMs, Raman and optical microscopes, beamlines, and more



**Hysitron PI 88 SEM PicoIndenter**  
The Ideal Choice for SEM and FIB/SEM

- Truly quantitative nanoscale mechanical characterization with direct observation
- Advanced XYZ sample positioning with optional tilt and rotation stage
- Modular design supports our full suite of testing techniques, including 800°C heating, scratch, extended range load cell, electrical biasing, and more



**Hysitron PI 95 TEM PicoIndenter**  
Quantitative Nanomechanical Testing Inside Your TEM

- The first full-fledged depth sensing indenter for TEM
- Testing modes include indentation, compression, tensile, bend, and scratch
- Specifically designed to interface with major TEM models (FEI, Hitachi, JEOL, Zeiss)

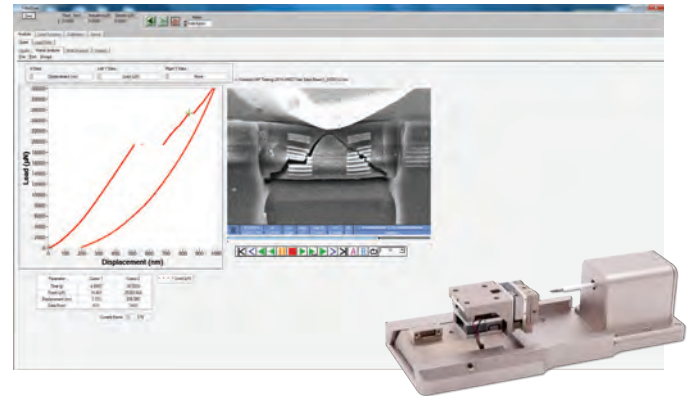
## ● Easily Add Quantitative Mechanical Testing

### Gain Insights Into Mechanical Performance at the Nanoscale

Acquire the mechanical data you need using familiar equipment already in your lab. Extend the capabilities of your microscope to include:

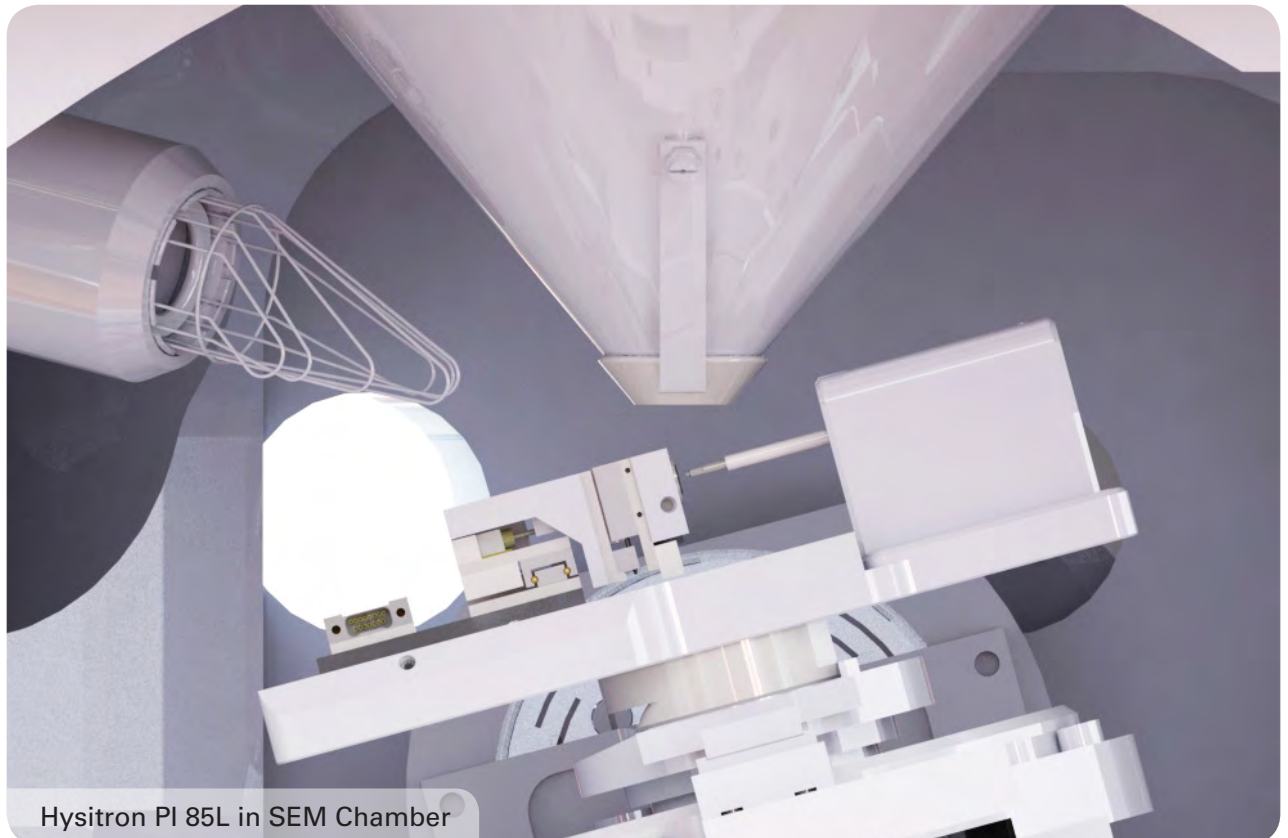
- Nanoindentation
- Microbeam Bending
- Pillar or Particle Compression
- Tensile Testing
- Nanoscratch

Pairing these capabilities with the real-time imaging provided by your microscope allows you to see the influence of defects, mechanical strain and thermal or electrical stimuli on the performance, lifetime and durability of engineered materials—from nanometer-to-micrometer scales.



### Uncompromised Stability Throughout Your Experiment

Bruker's in-situ solutions are designed for exceptional performance within the microscope environment. All considerations related to vacuum compatibility, detector positioning and frame compliance have been incorporated. Our proprietary transducer technology assures the highest degree of sensitivity and stability for superior nanomechanical measurements throughout your tests, while our digital controller provides ultra-fast feedback and data acquisition rates. High-magnification analysis is performed before, during, and after the stress-induced deformation process.



Hysitron PI 85L in SEM Chamber

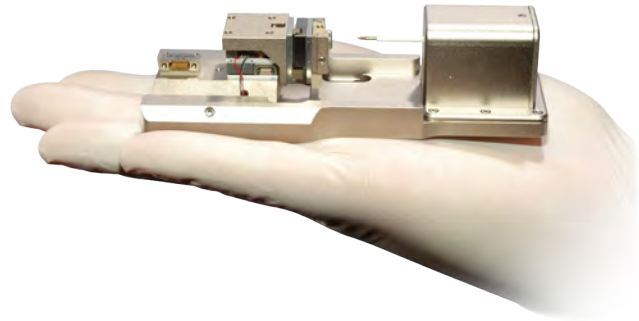


## ● In-Situ Nanomechanics Inside Your SEM

# Hysitron PI 85L SEM PicoIndenter

## Versatile In-Situ Mechanical Testing Platform

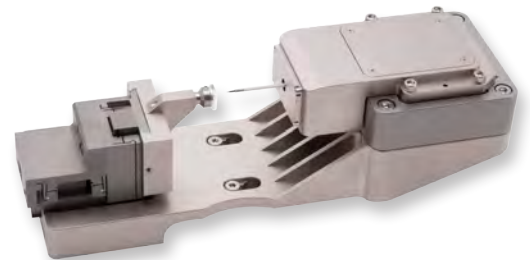
The Hysitron PI 85L is the next-generation version of our dedicated in-situ nanomechanical test instrument, designed for use in SEM but suitable for a variety of platforms and environments. Featuring Bruker's capacitive transducer working in conjunction with an extremely fast 78 kHz control system, the Picoindenter provides exceptional performance and superior stability at the nanoscale. The compact, low profile design makes the system ideally suited for small-chamber SEMs, Raman and optical microscopes, beamlines, and more.



# Hysitron PI 88 SEM PicoIndenter

## The Ideal Choice for SEM and FIB/SEM

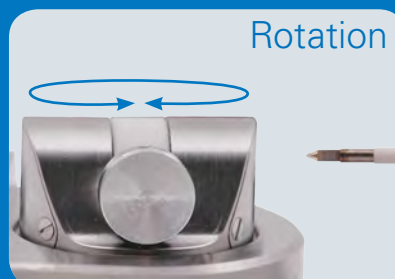
The Hysitron PI 88 is Bruker's comprehensive in-situ nanomechanical test instrument for SEM and FIB/SEM. Built upon Bruker's leading-edge capacitive transducer technology, the Hysitron PI 88 gives researchers an advanced instrument with powerful capabilities that delivers extraordinary performance and versatility. The modular design also supports our full suite of testing techniques for future upgradability, now including 800°C heating, scratch testing, 5-axis sample positioning, electrical characterization, dynamic fatigue testing, and an interchangeable extended range (500 mN, 150  $\mu$ m) transducer.



### Stability and Precision

The Hysitron PI 88 features a vacuum-compatible version of Bruker's nanoscale transducer and conductive diamond probe. The transducer applies force electrostatically while displacement is measured capacitively. The low-current design minimizes thermal drift and provides unprecedented sensitivity. Coupled with the transducer is an advanced XYZ sample positioning stage with >8 mm of range in all three axes, providing greater access to larger samples with superior lateral precision and linearity. This mechanical integration of the sample stage and the transducer on a single platform provides a stable, rigid foundation for nanomechanical testing.

**The Hysitron PI 88 is available with 3-axis (X, Y, Z) or 5-axis (X, Y, Z, tilt, rotation) sample-positioning stages.**



## ● In-Situ Nanomechanics Inside Your TEM

# Hysitron PI 95 TEM PicoIndenter

## Quantative Nanomechanical Testing Inside Your TEM

The Hysitron PI 95 instrument from Bruker is the first full-fledged depth-sensing indenter capable of direct-observation nanomechanical testing inside a transmission electron microscope (TEM). With this side-entry instrument, it is not only possible to image the mechanical response of nanoscale materials, but also to acquire load-displacement data simultaneously. Further, an integrated video interface allows for time synchronization between the load-displacement curve and the corresponding TEM video.



### Experimental Control

Coupling a nanomechanical test system with the TEM enables the researcher to determine certain test parameters *a priori*, such as variations in chemical composition or the presence of preexisting defects in the specimen. In addition to imaging, selected-area diffraction can be used to determine sample orientation and loading direction. Moreover, with in-situ mechanical testing the deformation event can be viewed in real-time rather than "*post mortem*." The pairing of these two high-resolution techniques provides the best of both worlds.

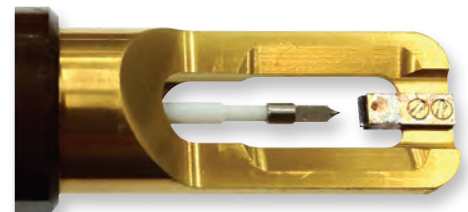
**The Hysitron PI 95 was specifically designed to interface with major TEM models.**

(FEI, Hitachi, JEOL, Zeiss)

### Unparalleled Performance

The Hysitron PI 95 utilizes three levels of control for tip positioning and mechanical testing. In addition to a three-axis coarse positioner and a 3D piezoelectric actuator for fine positioning, the instrument is equipped with a transducer for electrostatic actuation and capacitive displacement sensing. Two designs of transducers are currently available: a patented miniaturized transducer (JEOL compatible systems only) and a patented MEMS transducer. With these transducers, quantitative force-displacement curves can be acquired in-situ.

Unlike devices that rely on open-loop, piezo-controlled, series-loading mechanisms for indentation, which introduce unavoidable artifacts into the load-displacement curves, the Hysitron PI 95 transducer provides highly accurate depth-sensing capability. Furthermore, because of the electrostatic actuation aspect of the transducer, substantially larger forces can be realized without suffering a force sensitivity penalty.



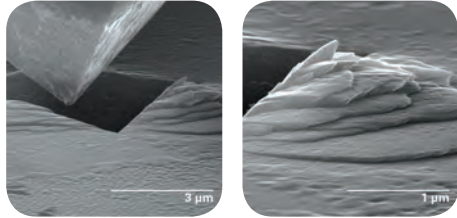
JEOL compatible front-end.



FEI/Hitachi/Zeiss compatible front-end with MEMS transducer.

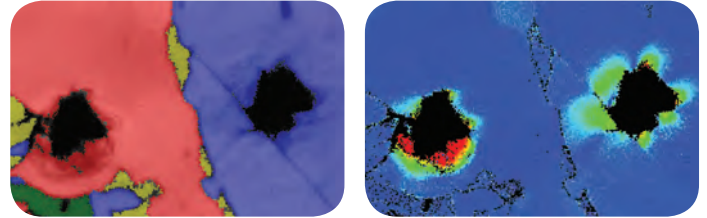
# ● Hysitron PI Series Testing Modes

## Nanoindentation



Real-Time Observation of Deformation

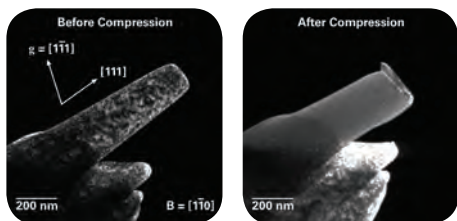
Targeted test placement for precise, site-specific measurement of hardness and elastic modulus, while observing the evolution of material deformation.



Nanoindentation Combined with EBSD

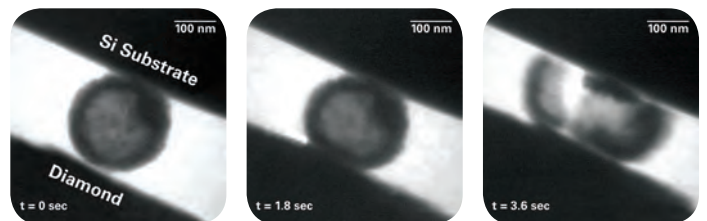
This combination of high spatial resolution techniques enables full microstructural characterization of metals and alloys. Measure hardness and elasticity of individual grains, then use EBSD mapping to correlate grain orientation with mechanical properties.

## Pillar and Particle Compression



Nanopillars

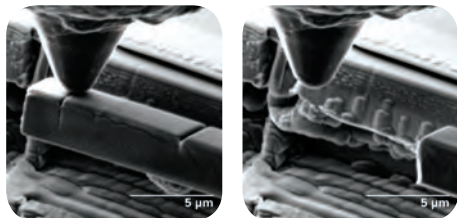
Observe the influence of compression on dislocations in material to measure yield strength and help predict material performance. [Nature Materials 7, 115-119 \(2007\)](#)



Particles

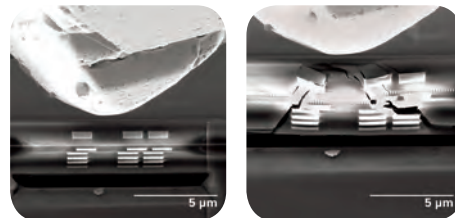
Verify proper tip alignment and test outcomes with SEM or TEM imaging and quantitatively evaluate new size/strength relationships of nano- and micro-sized particles for potential use as components in engineered materials.

## Cantilever and Microbeam Bending



Fracture Toughness of Interfaces

Isolate the interface of interest for direct observation, measurement, and analysis of failure mechanics. Uniform sample geometry lends itself to comparison with MD or FEM simulations.



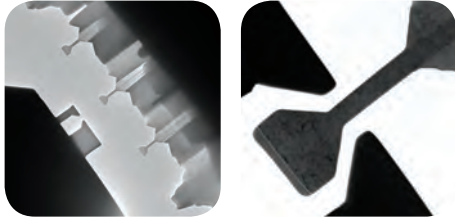
Predicting Failure in Multilayer Devices

Apply bending stresses to microbeams of layered, composite or multiphase structures to evaluate failure initiation points and observe damage progression through material and along interfaces.

[Vanstreeles, et. al., Applied Physics Letters 105, 213102 \(2014\)](#)

# ● Probe it. Bend it. Stress it. Measure it.

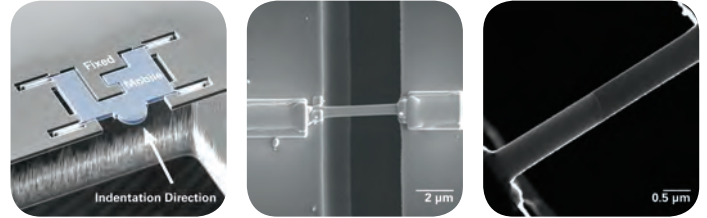
## Tensile Testing



Quantitative Direct Pull

Measure tensile properties and observe dislocation initiation, pinning, and interaction with defects and other deformation mechanisms.

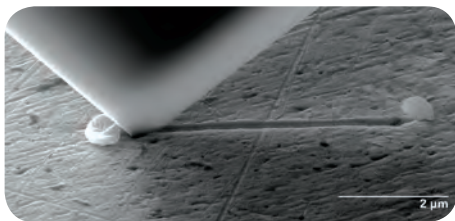
D. Kiener, et. al., *NanoLetters* 11, 9 (2011)



1D and 2D Materials

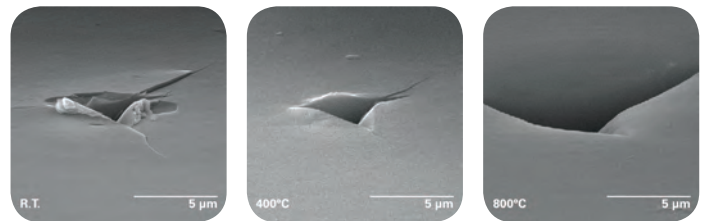
Nanowires and free-standing thin films can be mounted and tested in tension using a MEMS fabricated Push-to-Pull device. True stress and strain values are calculated directly from microscope measurements.

## Nanoscratch



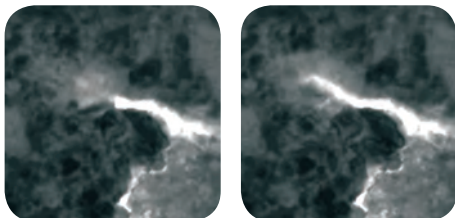
In-situ tribology sheds light on deformation processes occurring at the sliding interface. Friction properties can be measured while wear evolution is directly viewed.

## Heating



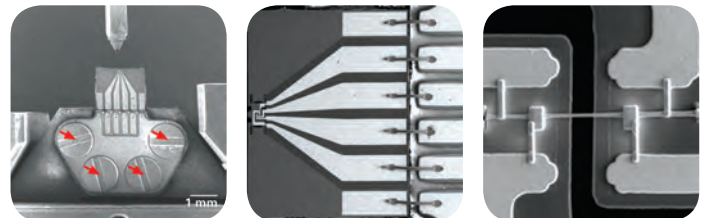
Add heating capabilities for direct measurement and observation of thermally initiated material transformations, ideal for testing materials that demand reliability under extreme conditions.

## Dynamic



Apply an oscillating force to continuously measure viscoelastic and fatigue properties as a function of depth and frequency.

## Electrical



Add testing capabilities for simultaneous measurement of electrical and mechanical properties during nanoindentation, compression or tensile loading to understand origins of electrical property changes in materials or devices.

## SEM PicoIndenter Specifications

Feature	Hysitron PI 85L	Hysitron PI 88
Max Force	10 mN / 30 mN	10 mN / 500 mN (optional)
Force Noise Floor	<0.4 $\mu$ N	<0.4 $\mu$ N / <5 $\mu$ N
Max Displacement	5 $\mu$ m	5 $\mu$ m / 150 $\mu$ m
Displacement Noise Floor	<1 nm	<1 nm
Feedback Control Rate	78 kHz	78 kHz
Max Data Acquisition Rate	39 kHz	39 kHz
Sample Positioning Range XYZ	>3 mm	>8 mm

## TEM PicoIndenter Specifications

Feature	Hysitron PI 95 for FEI / Hitachi / Zeiss TEMs	Hysitron PI 95 for JEOL TEM
Max Force	1 mN	1.5 mN
Force Noise Floor	<0.2 $\mu$ N	<0.2 $\mu$ N
Max Displacement	1 $\mu$ m	4 $\mu$ m
Displacement Noise Floor	<1 nm	<1 nm
Feedback Control Rate	78 kHz	78 kHz
Max Data Acquisition Rate	39 kHz	39 kHz
Fine Sample Positioning Range XYZ	50 $\mu$ m / 50 $\mu$ m / 3 $\mu$ m	50 $\mu$ m / 50 $\mu$ m / 3 $\mu$ m
Fine Sample Positioning Sensitivity XYZ	2 nm / 2 nm / 0.1 nm	2 nm / 2 nm / 0.1 nm
Coarse Sample Positioning Range XYZ	750 $\mu$ m / 750 $\mu$ m / 5000 $\mu$ m	750 $\mu$ m / 750 $\mu$ m / 5000 $\mu$ m

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